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AUTHOR Jung, Steven M.
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ABSTRACT

This report summarizes the mathematics component of Individually Prescribed Instruction (IPI). The first section outlines the overall goals, specific objectives, and philosophy of IPI; the organization of the materials; and the procedures for their use, with emphasis on the altered role of both students and teachers. The next section describes the origins of IPI, and names the key personnel (listing their philosophy and relevant research activities) and sources of funds. The third section describes the development of the IPI materials. The organization of the agencies concerned, the original development plan and subsequent modifications are outlined. Actual developmental procedures are detailed including the selection of demonstration schools, criteria for pilot schools, retraining of administrators and teachers, and formative evaluation.Final sections of this report outline summative evaluation, describe envisaged future developments, and list eleven decisions in the history of IPI Mathematics which are seen as having had a crucial effect on its course of development. (MM)

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PRODUCT DEVELOPMENT REPORT NO. 17

INDIVIDUALLY PRESCRIBED INSTRUCTION—MATHEMATICS (IPI—MATH)

DEVELOPED BY
LEARNING RESEARCH AND DEVELOPMENT CENTER, UNIVERSITY OF PITTSBURGH;
RESEARCH FOR BETTER SCHOOLS, PHILADELPHIA, PENNSYLVANIA;
APPLETON-CENTURY-CROFTS, INC., NEW YORK, NEW YORK;
BALDWIN-WHITEHALL SCHOOL DISTRICT, PITTSBURGH, PENNSYLVANIA

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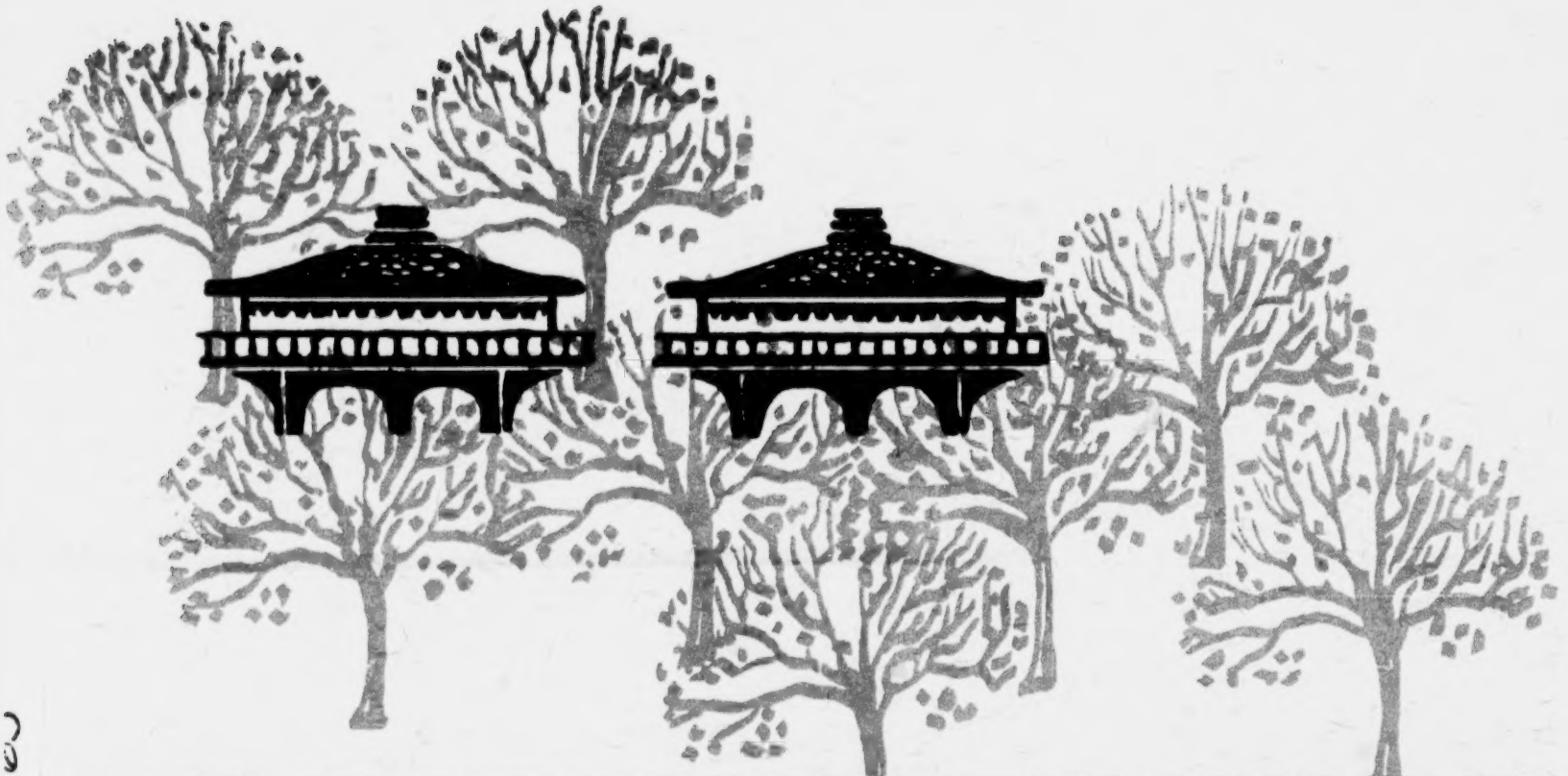

AMERICAN INSTITUTES FOR RESEARCH
Post Office Box 1113 / Palo Alto, California 94302

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Steven M. Jung

American Institutes for Research
in the Behavioral Sciences

Palo Alto, California

January, 1972

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U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Office of Program Planning and Evaluation

PREFACE

This product development report is one of 21 such reports, each dealing with the developmental history of a recent educational product. A list of the 21 products, and the agencies responsible for their development, is contained in Appendix C to this report. The study, of which this report is a component, was supported by U.S. Office of Education Contract No. OEC-0-70-4892, entitled "The Evaluation of the Impact of Educational Research and Development Products." The overall project was designed to examine the process of development of "successful educational products."

This report represents a relatively unique attempt to document what occurred in the development of a recent educational product that appears to have potential impact. The report is based upon published materials, documents in the files of the developing agency, and interviews with staff who were involved in the development of the product. A draft of each study was reviewed by the developer's staff. Generally, their suggestions for revisions were incorporated into the text; however, complete responsibility for interpretations concerning any facet of development, evaluation, and diffusion rests with the authors of this report.

Although awareness of the full impact of the study requires reading both the individual product development reports and the separate final report, each study may be read individually. For a quick overview of essential events in the product history, the reader is referred to those sections of the report containing the flow chart and the critical decision record.

The final report contains: a complete discussion of the procedures and the selection criteria used to identify exemplary educational products; generalizations drawn from the 21 product development case studies; a comparison of these generalizations with hypotheses currently existing in the literature regarding the processes of innovation and change; and the identification of some proposed data sources through which the U.S. Office of Education could monitor the impact of developing products. The final report also includes a detailed outline of the search procedures and the information sought for each case report.

Permanent project staff consisted of Calvin E. Wright, Principal Investigator; Jack J. Crawford, Project Director; Daniel W. Kratochvil, Research Scientist; and Carolyn A. Morrow, Administrative Assistant. In addition, other staff who assisted in the preparation of individual product reports are identified on the appropriate title pages. The Project Monitor was Dr. Alice Y. Scates of the USOE Office of Program Planning and Evaluation.

Sincere gratitude is extended to those overburdened staff members of the 21 product development studies who courteously and freely gave their time so that we might present a detailed and relatively accurate picture of the events in the development of some exemplary educational research and development products. If we have chronicled a just and moderately complete account of the birth of these products and the hard work that spawned them, credit lies with those staff members of each product development team who ransacked memory and files to recreate history.

TABLE OF CONTENTS

	Page
PREFACE	ii
LIST OF FIGURES	iv
PRODUCT DESCRIPTION	
Product Characteristics	1
Rationale for Product	1
Description of Materials	4
Procedures for Using Product	6
ORIGINS	
Key Personnel	11
Funding for Product Development	14
PRODUCT DEVELOPMENT	
Management and Organization	15
Original Development Plan	19
Modification of Original Development Plan	25
Actual Procedures for Development of Product	26
SUMMATIVE EVALUATION	34
FUTURE OF THE PRODUCT	36
CRITICAL DECISIONS	36
REFERENCES	40
APPENDIX A: IPI DEVELOPMENT COSTS (RBS)	41
APPENDIX B: ACTIVITIES PERFORMED BY INDIVIDUALIZED LEARNING PROGRAMS PERSONNEL IN THE FIVE MAJOR FUNCTIONAL AREAS	42
APPENDIX C: LIST OF PRODUCTS AND DEVELOPERS	43

LIST OF FIGURES

Figure — Page

1. Research for Better Schools, Inc. Operating Network: Fiscal 1971 16

2. Learning Research and Development Center Research Organization Chart 18

3. A Diffusion Model 20

4. Phases of IPI Diffusion 21

5. Major Event Flow Chart 22

PRODUCT DESCRIPTION

Product Characteristics

Name

Individually Prescribed Instruction--Mathematics (IPI--Math)

Developer

Learning Research and Development Center, University of Pittsburgh; Research for Better Schools, Philadelphia, Pennsylvania; Appleton-Century-Crofts, Inc., New York, New York; Baldwin-Whitehall School District, Pittsburgh, Pennsylvania.

Distributor

Research for Better Schools, Philadelphia, Pennsylvania; Appleton-Century-Crofts, New York, New York.

Focus

Mathematics.

Grade Level

Grades K-6.

Target Population

All students in grades K-6.

Rationale for Product

Long Range Goals of Product

The major long range goal of the IPI program is to permit pupils to proceed through a sequenced set of objectives for mathematics, and at a pace that is determined by individual abilities and interests. This program would be made possible by the total restructuring of the elementary school curriculum and the instructional management system which exists in most elementary schools. This, of course, requires sequences of instructional objectives that represent a continuity not broken by grade levels or classes. The working aims of the IPI project, which are derived from this major goal and from the definition of individualization, are as follows:

1. To provide for reliably assessable individual differences among learners.

2. To develop mastery of subject matter as the child moves through the curriculum.

3. To develop self-directed and self-initiated learners through instructional procedures which provide for self-selection and self-evaluation.

4. To provide opportunities for the child to become actively involved in the learning process.

The IPI procedure is not limited to any particular type of content objectives, nor is IPI a curriculum project whose purpose is teaching new and different subject matter. Rather, it is a set of procedures for planning and carrying out instruction that can be applied to any content for which objectives can be defined in specific behavioral terms and organized in some meaningful sequences. In actuality, then, IPI Math is one important aspect of the overall Individually Prescribed Instruction system which also includes curriculum materials for reading, spelling, handwriting, science, and social studies.

Objectives of Product

The objectives of IPI Math are stated as a set of carefully sequenced and detailed student performance objectives which describe the behaviors that a learner will be able to perform when he has mastered the objectives. Specific teaching methods, learning materials, and diagnostic instruments are identified for each objective. Currently, 363 instructional objectives exist for IPI Math in each of ten content areas or units. These ten units are as follows: numeration/place value, addition/subtraction, multiplication, division, fractions, money, time, systems of measurement, geometry, and applications. This set of objectives is also divided into levels which roughly correspond to grades within the elementary curriculum. There are 40 objectives at level A, which roughly corresponds to kindergarten. There are 48 objectives at level B, which roughly corresponds to grade 1. There are 65 objectives at level C, 59 at level D, 62 at level E, 41 at level F, and 48 at level G, which roughly correspond to grades 2-6. An example of an addition/subtraction objective at level A is the following:

> Given two sets of objects, the student adds objects or takes objects away from a set to make the two sets equivalent.

An example from level E geometry is as follows:

> Given the words equilateral triangle, right triangle, or quadrilateral, the student can draw or select the appropriate figure.

These objectives are modified considerably from the original set of 430 objectives which were identified for the 1966-67 version of IPI Math.

Philosophy Behind Product

The philosophy of Individually Prescribed Instruction may be described as an attempt to apply principles of educational programming and instructional design to the entire school curriculum. These principles are as follows:

1. A first step in the development of a program must be the clear and specific definition of the objectives that the pupils are expected to achieve.

2. The development of a program requires that the behaviors leading to the attainment of terminal student objectives be carefully analyzed and sequenced in a hierarchical order such that each behavior builds on the objective immediately below it in the sequence and is prerequisite to those that follow it.

3. The actual instructional content of a program consists of a sequence of learning tasks or activities through which a student can proceed with little outside help and provides a series of small increments in learning that enable the student to proceed from a condition of lack of command of the terminal behavior to that of command of it.

4. A program permits a student to start at that level at which his present ability and achievement indicate that he is functioning and permits him to move on from that point.

5. In the use of a program, each pupil can usually proceed independently of other pupils and can learn at a rate best suited to his abilities and interests.

6. A program requires active involvement and response on the part of the pupil at each step of the learning sequence.

7. A program usually provides for rather immediate feedback to the student concerning the adequacy of his performance on each frame or element of the program.

8. A program is subjected to continuous study by those responsible for it and is regularly modified in light of available evidence concerning pupil performance.

The following assumptions underlie these principles. First, learning is something that is ultimately personal and individual. Learning may take place within a social context, and many types of instruction are traditionally carried out with groups of students. However, it is the individual who learns, not the group. This, in turn, dictates that instructional plans should be prepared for the individual, not for the group.

A second assumption is that the type of planning that is employed in good instructional programming may be employed to cover an extensive program which extends over grade lines covering at least all of the elementary school years and which involves a greater variety of learning experiences than can be presented in a textbook. Conditions should be such that an extremely bright first grade pupil, for example, might master all of the skills and content that are traditionally taught during the first three or four years of school. On the other hand, another student might take two or three years to acquire the skills and content that the average child masters in one year. These basic assumptions require a restructuring of both the learning methods and materials and the traditional teacher roles of conventional mathematics instruction.

Description of Materials

Organization of Materials

Materials for IPI Math exist for two separate components. The first component consists of those materials that are used directly for classroom instruction. The second component consists of those that are used for training teachers and administrators in the proper techniques for utilizing IPI.

Materials for the classroom component consist of assessment services, student learning materials, and classroom management documents. Assessment devices consist of placement tests, pre- and post-unit tests and curriculum-embedded tests. Student learning materials consist of IPI-constructed booklets, entitled "Standard Teaching Sequence Booklets," one of which exists for each objective or set of objectives in each unit at each level. IPI Math consists of several hundred such booklets. The materials in these booklets

have been adapted from pre-existing instructional materials or have been constructed by IPI staff to produce the attainment of desired student outcomes as specified by the objectives of IPI. The activities in these booklets resemble the frames of a programmed instructional text, requiring active student responses. Classroom management documents consist of student progress profiles, placement profiles, and prescription writing sheets which assist teachers in the development of individual student prescriptions based on test results and prior teacher knowledge about the characteristics of individual students. In addition, teachers are urged to construct lists of teaching resources available in their own classrooms which would be keyed to the objectives of the various units of IPI Math, such that they can refer to these resources in writing student prescriptions. Tests and student materials sometimes make use of audiotapes and other audiovisual equipment. These external resources are referenced in the teaching booklets so that students may utilize them without extensive assistance by the teacher or her aide.

Teacher training materials, developed by Research for Better Schools, include programmed booklets and audiovisual materials. The basic teacher training course is contained in six volumes entitled "Teaching the IPI Mathematics." The first volume is entitled "Individualized Instruction and IPI;" the second volume is entitled "Behavioral Objectives and the IPI Mathematics Continuum;" the third volume is entitled "Diagnosis of Student Achievement;" the fourth volume is entitled "Developing a Prescription, Case Study One;" the fifth volume is entitled "Developing a Prescription, Case Study Two;" and the sixth volume is entitled "Developing a Prescription, Case Studies 3, 4, and 5." These materials contain guidelines for using all of the IPI materials, including the tests, and contain suggestions for proper procedures for organizing the classroom and writing student prescriptions. The packages are generally individualized so that the head administrator or principal at a school can lead his faculty through the program. In addition, most teachers attend a summer training workshop in Individually Prescribed Instructional procedures, which is conducted by Research for Better Schools at several geographical locations around the country.

The cost for the student materials component is currently $10 per pupil per year (1970-71 school year). The IPI Math program will become commercially available in September of 1972. At that time it is hoped that recurring costs per student per year can be lowered to the neighborhood of $5.00-$7.50. Costs

for the teacher training component are currently borne by Research for Better Schools as part of their continuing attempt to revise and improve the strategy for training teachers for IPI. These costs do not include the cost of the teacher aides which are required to implement the program.

Procedures for Using Product

Learner Activities

Relationship to program objectives. Learner activities are highly related to program objectives. Students are placed into the sequence of objectives on the basis of their demonstrated mastery of objectives on the placement tests. Once placed, a student works on activities and materials which are keyed directly to the intended behavioral outcomes expressed by the program objectives. Since these objectives are expressed in terms of what the pupil should be able to do after he has mastered the objective, the essential focus of instruction is to provide conditions under which the pupil can practice the relevant behavior. For example, if the objective states that the pupil should be able to solve problems of a particular type, lesson materials provide guided practice in the solving of such problems. Further, in IPI an attempt is made to keep the student continuously informed regarding his progress toward mastery of these goals and objectives. His worksheets are scored either by himself or by a teacher-aide immediately after completion. These scores, along with check-tests called Curriculum Imbedded Tests, serve both the pupil and the teacher in monitoring his progress within his unit of study.

Children typically work individually or in small groups of from two to six. There are several teacher-aides available to score curriculum-embedded tests and record progress. When a child finishes a work sequence and has had his work corrected, he receives a prescription for a new sequence from one of his teachers. The prescription is based upon the level of mastery he has demonstrated on the work just completed. The basic procedure in relating the student to the curriculum is as follows. A diagnostic placement test is given for each subject area or unit. This allows a rough placement of the student into levels and units within levels. After placement, but before beginning work assignments in a given unit, the student is given a pretest for the lowest unit in which he failed to demonstrate mastery. The pretest

allows more specific placement in terms of the basic skills which make up that unit. From 1 to 14 objectives may comprise a unit, and a student may be placed into work on any one of these objectives based on his performance on the unit pretest. If mastery of a particular skill (objective) is demonstrated on a pretest, the student is moved on to another skill for which he does not show mastery. The teacher generates prescriptions and the student then works until mastery is achieved, as demonstrated by his performance on the unit posttest. One prescription usually contains enough material to provide a student with work ranging from one day to a week, depending on the student's ability, the type of units being studied, and the number of experiences prescribed. The student "fills" his prescription by first obtaining materials from the learning center and then working independently or in large or small groups, receiving teacher attention when needed. The net result is that the student never engages in formal study in areas whose objectives he has already mastered.

Although a student may engage in contact with IPI Math materials only about one hour per day, depending upon grade level, materials are actually designed to be used within the total IPI context in which the student would work on other IPI materials in reading and the other subject matter areas for the entire day. IPI has just begun to exploit techniques which capitalize on peer-tutoring arrangements and increased student self-assessment. Classroom management procedures are being developed to provide appropriate reinforcing contingencies and incentives to maximize student attention and subject matter exploration. Freer arrangement of the school day is being considered, whereby students could select their particular tasks for a period of time and not be bound to so many minutes of a subject each day. When IPI Math is utilized in isolation, as it must be in some situations, the remaining subject areas may be taught through more conventional methods.

Teacher Activities

It is evident that the teacher's role within this individualized education system is considerably different than the role required under conventional lock-step group instruction. One way of describing this role is to outline it in terms of three major functions. These are: (1) the teacher's role in operating the system; (2) the teacher's role in supplementing the system and to enhance its adaption to individual needs; and (3) the teacher's

role in providing for the achievement of goals possible only with teacher-attention.

Of course, the basic aspect of the teacher's role in IPI is to allow the system to function. This includes such activities as the following:

1. The evaluation and diagnosis of prior student achievement level utilizing tests supplied by the system.

2. The development of individual study plans or prescriptions unique to the needs of each individual student.

3. The development of immediate and long range plans for the total class which take individual needs and prescriptions into account.

4. The planning and organization of the classroom and the class period to create an effective learning environment.

5. The development, in cooperation with other members of the professional staff, of procedures for utilizing the services of paraprofessionals or teacher-aides.

6. The study and evaluation of the system so as to improve its operation in the classroom.

In supplementing the system to enhance its adaptation to individual student needs, it is essential that certain aspects of evaluation, diagnosis, prescription, and instruction be carried out to a degree more than that which is required by the simple mechanics of the classroom management system. Such intervention by the teacher may involve providing personal tutoring or some other type of personal instruction for the student. It may involve a decision to involve peer tutoring, arranging for one student to instruct another. Frequently, it will result in a decision to use small group or large group instruction when either is deemed to be the most effective procedure for achieving certain goals. It is essential that the teacher be able to make exceptions and adapt the system when it is necessary. One example of this would be a decision to lower the mastery requirement on a skill or unit for a given pupil. Another might be the decision to have a student skip certain units.

If a program for individualized instruction is to achieve the basic goal of developing students who have an interest in learning and who have the capacity for setting goals and carrying out a self-directed study program designed to achieve those goals, it is important that the system provide for

a number of experiences that can only be carried out through personal involvement of the teacher. These roles demand that the teacher act as a counselor and listener. This means that when the teacher is moving around the classroom and interacting with students, an important aspect of this interaction must be an attentiveness to their concerns and problems. If a student is to become a willing and interested learner, it is important that his experiences with learning be in situations where he feels an attentiveness and receptivity to his particular needs. At still higher levels the teacher's role will involve assisting students in mapping out paths that will result in the attainment of certain long range goals such as the pupil's becoming a self-activated and self-directed learner. Situations involving individualized instruction as provided by IPI present unique opportunities for the teacher to become aware of each pupil's progress in the development of important types of attitudes, values, and personal-social skills.

Teacher training. Teacher training in IPI is based on the same principles upon which student materials are based. This includes behavioral objectives and diagnostic instruments. The training program is usually conducted by the school administrator, who has received training from Research for Better Schools on the basic aspects of dealing with IPI. These aspects include the following:

1. To develop strategies for training teachers for IPI.
2. To learn the operation and procedures of IPI.
3. To learn the administrative tasks involved in implementing IPI.
4. To develop communication skills useful in implementing IPI.
5. To formulate a plan for the successful operation of IPI in his individual school.

The training materials developed by Research for Better Schools provide six types of activities. The first is building educational concepts related to IPI; the second is analysis and application of these concepts to IPI; the third is practice in using skills and materials as routine exercises; the fourth is role-taking of teacher-aide and student while working through the math continuum; the fifth is discussion designed to provide an opportunity for clarification; and the sixth is the expression of reactions to IPI.

Several weeks are usually required for the successful completion of these teacher training activities. However, they may go on simultaneously with classroom instruction, thus increasing the time necessary for out-of-class preparation.

Out-of-class preparation. Out-of-class preparation for IPI is probably as extensive as that required for any educational program identified in this project. For this reason, it has been imperative to utilize the services of classroom aides to assist the professional teacher. The classroom aides handle the routine clerical tasks of administering and scoring tests, recording data, preparing materials, and monitoring student performance, leaving the teachers free for broader training related to the development of prescriptions for individual students and the other roles mentioned above. The actual amount of teacher out-of-class preparation depends on the extent to which IPI is implemented for the entire curriculum. If only math is involved, one hour of preparation for every hour of classroom instruction is about average.

Provision for Parent/Community Involvement

There are no specific provisions within IPI Math for parent/community involvement.

Special Physical Facilities or Equipment

At present, no special facilities or equipment are needed. The classroom organization is generally such that a materials center, a tutoring, prescription, and test taking area, and an individual student study area are desirable. In addition, the employment of several paraprofessional aides per class is a prerequisite.

Recommended Assessment Techniques for Users

As has been noted above, diagnosis of pupil achievement utilizing criterion-referenced tests plays a vital role in Individually Prescribed Instruction. Each time a pupil is to be assigned a new instructional unit during any part of the school year, his teacher must have knowledge about what that individual pupil does or does not know. Knowledge of the entering achievement level of a pupil can be utilized by the teacher in planning an efficient and effective program tailored to the individual. As the pupil proceeds by working on the prescribed instructional materials, the teacher must be concerned with monitoring his progress; the continuous diagnosis of

achievement provides necessary feedback for further planning and modification of individual programs as well as motivation to students. The testing program provides placement tests: unit, pre- and posttests, and curriculum-embedded tests.

ORIGINS

Key Personnel

To Dr. Robert Glaser goes much of the credit for development of the concepts which are prerequisite to the IPI system. Dr. Glaser received his Ph.D. from Indiana University and served in the aviation psychology program of the Army Air Force during World War II. He has taught at the University of Indiana, the University of Kentucky, the University of Illinois; and has served on the Board of Research Advisors for the American Institutes for Research. Since 1965, he has been a professor of education and psychology at the University of Pittsburgh. During the early 1960's, Dr. Glaser became nationally known for his work in programmed instruction. He is the editor, along with Arthur Lumsdaine, of Teaching Machines and Programmed Learning: A Source Book published by the National Education Association in 1960. Dr. Glaser also edited the 1962 publication entitled Training Research in Education from which he derived his original conception of an IPI model. His 1963 article in the American Psychologist, entitled "Instructional Technology and the Measurement of Learning Outcomes: Some Basic Questions," is generally credited as providing the origin of the term "criterion-referenced measurement." Dr. Glaser edited the 1965 NEA sequel to Teaching Machines and Programmed Learning: A Source Book entitled Teaching Machines and Programmed Learning II: Data and Directions.

Other key personnel at the Learning Research and Development Center (LRDC) of the University of Pittsburgh include: Dr. John Bolvin, who is Director of the Individually Prescribed Instruction project at LRDC; Dr. C. M. Linvall, who is Associate Director of LRDC; Dr. William W. Cooley, who is Co-Director of LRDC; and Drs. Glen Heathers, Lauren Resnick, Richard C. Cox, Joseph I. Lipson, John L. Yeager, and Richard L. Ferguson. At the regional laboratory, Research for Better Schools, Dr. James W. Becker and Dr. Robert G. Scanlon, Executive Director and Program Director for the Individualized Learning Program, respectively, have held major responsibility

for the continuing development and dissemination of IPI. Both of these men received their initial contact with the IPI project while employed by public schools in the Pittsburgh area--Dr. Becker as Director of Research for the Pittsburgh Board of Education and Dr. Scanlon as Principal of Oakleaf Elementary School. In addition, personnel of the Baldwin-Whitehall School District of suburban Pittsburgh, including Dr. W. R. Paynter, Superintendent, also cooperated in the development of IPI.

Philosophy of Key Personnel

The essential element in the philosophy of all of the above-mentioned key personnel is the stress on the utilization of the techniques of programmed instruction to bring about an individualization of the education process as a whole. This represents a belief that educational methods and materials can be structured such that, given enough time, almost every student can master a basic set of educational objectives. Individualized rate of instruction has not been a new notion in American schools. The roots of this philosophy may be traced back to the Winnetka Plan in the early 1920's, as articulated by Carl Washburn in a 1925 edition of the National Society for the Study of Education Yearbook. IPI is thus not a completely new set of ideas, but a re-examination and re-assumbly of many previously articulated concepts.

Relevant Research Conducted by Key Personnel

The first attempt to individualize the elementary school curriculum came about as a result of a series of exploratory studies begun in 1961 and 1962 at the University of Pittsburgh. These studies were designed to test preliminary notions about the feasibility of such a system based on the use of programmed instructional materials in an intact classroom in which teaching practices were oriented around the conventional grade-by-grade progression of learning. The motivation behind this series of studies was to examine student achievement when the basic subjects (reading and math) were taught largely by programmed instruction in the elementary school; and to suggest what this examination might mean for the improvement of instructional practice and the development of a research-based instructional system. The findings of this research, stated as broad generalizations, were as follows:

1. There is extensive variation in the rate of learning among students when they are given the opportunity to proceed at their own rates with programmed learning materials.

2. Pretest scores show that many of the students know the subject being taught but that some students are not yet ready to learn it.

3. Different types of teacher/program combinations in several grades may make little difference in student achievement.

4. Young children can be taught a subject intensively with little loss of retention.

5. The extent of the correlation between general intelligence and achievement as a result of programmed instruction depends upon the particular program involved. In general, intelligence appears to be related to the pace with which a student goes through a program.

6. Extension of a curriculum with programmed materials necessarily taking away some time spent in conventional grade level instruction can produce additional learning without being detrimental to the learning materials usually used at that grade level.

7. In general, students who are required to learn more do so.

When the results of these studies were more fully analyzed, it was apparent that the significant individualization feature of programmed instruction could not be manifested unless the intact classroom changed its organization to permit a more flexible progression. Out of this experience grew the various combinations of instructional materials, assessment and data management techniques, and teacher practices that came to be called Individually Prescribed Instruction.

During the school year 1963-64, the Learning Research and Development Center and the Baldwin-Whitehall Public Schools of suburban Pittsburgh initiated an experiment to investigate the feasibility of converting an entire K-6 school to a system of individualized instruction. It should be noted that at this time programmed instruction was riding a crest of wide public interest and acceptance which was to fade as the decade wore on. In addition, the "mastery learning" concept articulated by John Carrol (1963) was also widely acclaimed.

The passage of Title IV of the Cooperative Research Act enabled the Learning Research and Development Center to be founded early in 1964. This provided the funding which was needed for entering into the cooperative project with the Baldwin-Whitehall School District at the Oakleaf School.

A needs assessment conducted by Research for Better Schools, utilizing data from the Project TALENT survey of 1960 and from a 79-item inventory of teacher preferences jointly developed by AIR and Research for Better Schools (RBS) staff, demonstrated that a primary concern of elementary teachers in the RBS area was the development of programs which had heavy emphasis on individual diagnosis and programming, including such features as tutoring, the utilization of paraprofessionals, and the wide scale employment of remedial teachers and specialists in reading, language arts, and communication. The data further suggested that educational programs currently planned to meet these needs were inadequately described, poorly structured, and incapable of replication and evaluation.

Funding for Product Development

Funds for the development of IPI Math have come from four sources. Basically, these sources are:

1. U. S. Office of Education, through funding to the University of Pittsburgh Learning Research and Development Center, and through funding to the regional laboratory for Pennsylvania, Delaware, and New Jersey, Research for Better Schools, Inc.

2. The University of Pittsburgh, with additional grant and contract support from the Andrew W. Mellon Educational and Charitable Trust, the Carnegie Corporation of New York, the Ford Foundation, and the Office of Naval Research.

3. Funds from the Baldwin-Whitehall School District.

4. Considerable developmental monies provided by the Appleton-Century-Crofts Publishing Company.

All of these funding sources had a basic interest in procedures to better individualized education, and indeed the Learning Research and Development Center at the University of Pittsburgh and the regional laboratory, Research for Better Schools, were both founded for the basic purpose of utilizing research findings in the development of learning methods and materials for the individualization of instruction. This goal was to be carried out by the development of effective prototype models of instructional procedures which could then be disseminated and brought into general educational practice. As programs were developed, they were to be continually evaluated through the collection of data to provide evidence of the effectiveness of

the program, which in turn could be analyzed in such a way as to provide specific implications for further improvement. An operational principle was that effective educational change comes about most rapidly through development and demonstration of full-blown programs which include the necessary material, teacher training, and environmental design to make them operational in a school setting. Appendix A contains a breakdown of the primary development and dissemination costs of IPI secured from RBS from 1966 to the present. We were unable to secure figures on the initial development costs of IPI Math from LRDC.

PRODUCT DEVELOPMENT

Management and Organization

Characteristics of Development Agency

Although several major agencies have been involved in the development of IPI Math, it is not unfair to consider the regional laboratory, Research for Better Schools, as the major development agency. Research for Better Schools took IPI Math from a fairly primitive stage in Oakleaf School to its present state, including installation in more than 300 schools around the country. Additional responsibility for the development of IPI may be credited to the Learning Research and Development Center at the University of Pittsburgh, the Baldwin-Whitehall School District, and Appleton-Century-Crofts Publishing Company.

Research for Better Schools was founded in 1966 as the regional laboratory for Eastern Pennsylvania, Delaware, and New Jersey. As has been mentioned earlier in this document, one of its primary missions from the time the laboratory was founded was the development and dissemination of IPI. Research for Better Schools is currently one of the largest of the regional laboratories in terms of annual U. S. Office of Education budget. Fifty-two percent of this budget in FY'71 went to the Individualized Learning Program, whose main component is Individually Prescribed Instruction.

The organization of the laboratory is shown in Figure 1. Out of a total professional staff of 139, approximately 79 are employed in the Individualized Learning Program. Of these, approximately 45 work on the development and dissemination of Individually Prescribed Instruction. This represents a significant gain from three professional staff in 1966 and six in 1967. These staff members are principally professional educators and personnel

Figure 1

Research for Better Schools, Inc.
Operating Network: Fiscal 1971

The focus of the Laboratory is on those activities which optimize opportunities for individualizing and humanizing learning.

CORPORATE POLICY AND PLANNING

PROGRAM SUPPORT

INDIVIDUALIZING LEARNING PROGRAM	HUMANIZING LEARNING PROGRAM	ADMINISTERING FOR CHANGE PROGRAM
Developing, testing, and disseminating programs which individualize instruction through the application of learning theories and technology.	Optimizing the affective, cognitive, and interpersonal human potential of the learner through new types of curriculum content and appropriate teaching techniques.	Developing change capabilities for implementation by educational institutions.
.Individually Prescribed Instruction .Individualized Learning for Adults (ILA) .Computer Applications	.Knowledge Base .Curriculum Development	.Knowledge Base .Organizing for Change .Planning for Change .Managing for Change

trained in educational administration and the disciplines of education and psychology. They are grouped into five distinct functional areas: (1) curriculum writing, (2) material production, (3) training, (4) field engineering, and (5) appraisal. The activities performed by personnel in each of these areas are indicated in Appendix B.

Other Agencies Involved in Development

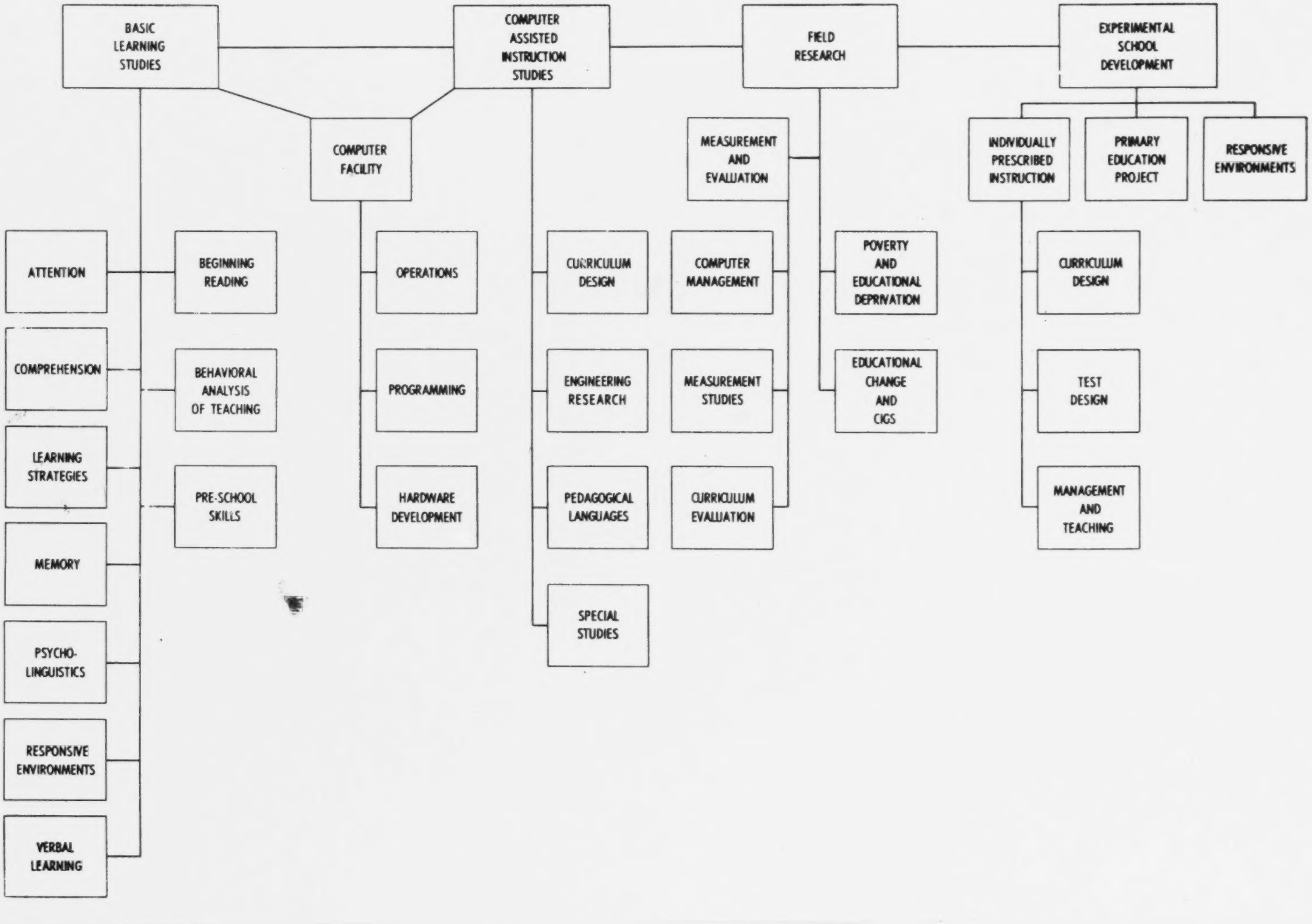
Of the other three agencies involved in the development of IPI, the major one is the Learning Research and Development Center at the University of Pittsburgh. Figure 2 indicates the organization of this center. It will be noted that Individually Prescribed Instruction comprises a much smaller percentage of the overall mission of the LRDC than is true of Research for Better Schools. LRDC served as the major initiator of IPI Math products, installing these products in the Oakleaf School of the Baldwin-Whitehall School District during the 1965-66 school year. The project was initiated at that time mainly as a feasibility study to determine the practicality of developing a system of procedures that would produce an educational environment highly responsive to differences among children.

Appleton-Century-Crofts Publishers secured a copyright on the early version of the IPI Math materials as they were being tried out in the Oakleaf School. In consideration for these copyrights, Appleton-Century-Crofts contributed expertise to the actual production of IPI Math materials.

Relationship to primary developer. The organizational arrangements between Research for Better Schools, the Learning Research and Development Center, and Appleton-Century-Crofts are not well defined. No formal document of agreement has ever been signed between RBS and LRDC. In general, however, the arrangement has worked as follows: RBS staff took materials which were being used in the Oakleaf School and produced them in quantity for use in the RBS demonstration and development schools. The early intent was to jump as quickly as possible into the practice of individualization in order to learn the specific requirements of that practice. A guiding assumption was that procedures would be continuously improved and refined on the basis of practical experience, and that new and improved substantive content of curriculum could then be developed within the requirements of individualization. This revision was carried out primarily under the aegis of staff from RBS with periodic inputs from LRDC and Appleton-Century-Crofts staff.

Figure 2

Learning Research and Development Center
Research Organization Chart



Revisions have been directed toward the production of the Mark II version of IPI, which will be marketed beginning September 1972. LRDC is now involved in developing and trying out at Oakleaf School what has been termed the Mark III version of IPI, stressing a more modern approach to the mathematics curriculum.

Original Development Plan*

The original development plan for IPI is contained in a document entitled "Interim Report of the Middle Atlantic Regional Laboratory," dated April 1, 1966. Examination of this plan indicates that the major activities envisioned by RBS were related to the dissemination and adoption process, rather than to the development process. This diffusion was conceptualized into five phases. Phase 1 was the identification of five cooperating school districts within the RBS region which would be willing to demonstrate and test IPI. Phase 2 would be the establishment of a demonstration training school in the Baldwin-Whitehall School District in addition to the Oakleaf School. Phase 3 involved the training of staff from the five pilot schools and the installation of the IPI program in those schools. Phase 4 was the evaluation and necessary revision of the IPI program. And, phase 5 was diffusion of the IPI program to other schools. Figure 3 reflects the diffusion model underlying these phases. The ultimate goal was the widespread diffusion and adoption of Individually Prescribed Instruction, as modified. Figure 4 provides an indication of the activities with which RBS had planned to bring about this wide-scale adoption. These activities are the ones marked with an asterisk. It may be seen that, in addition to the evaluation and revision of IPI materials, it was planned that RBS would conduct training for staff from the pilot schools and would participate with institutions of higher education in the RBS region to develop training and retraining programs necessary for the wider scale implementation of IPI. In addition, it was planned that RBS would solicit volunteers and conduct demonstrations for these volunteers in the IPI demonstration schools. It was intended that these activities would be completed by mid-1970.

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*See Figure 5 for a diagram of the major events in the history of the product.

Figure 3. A Diffusion Model

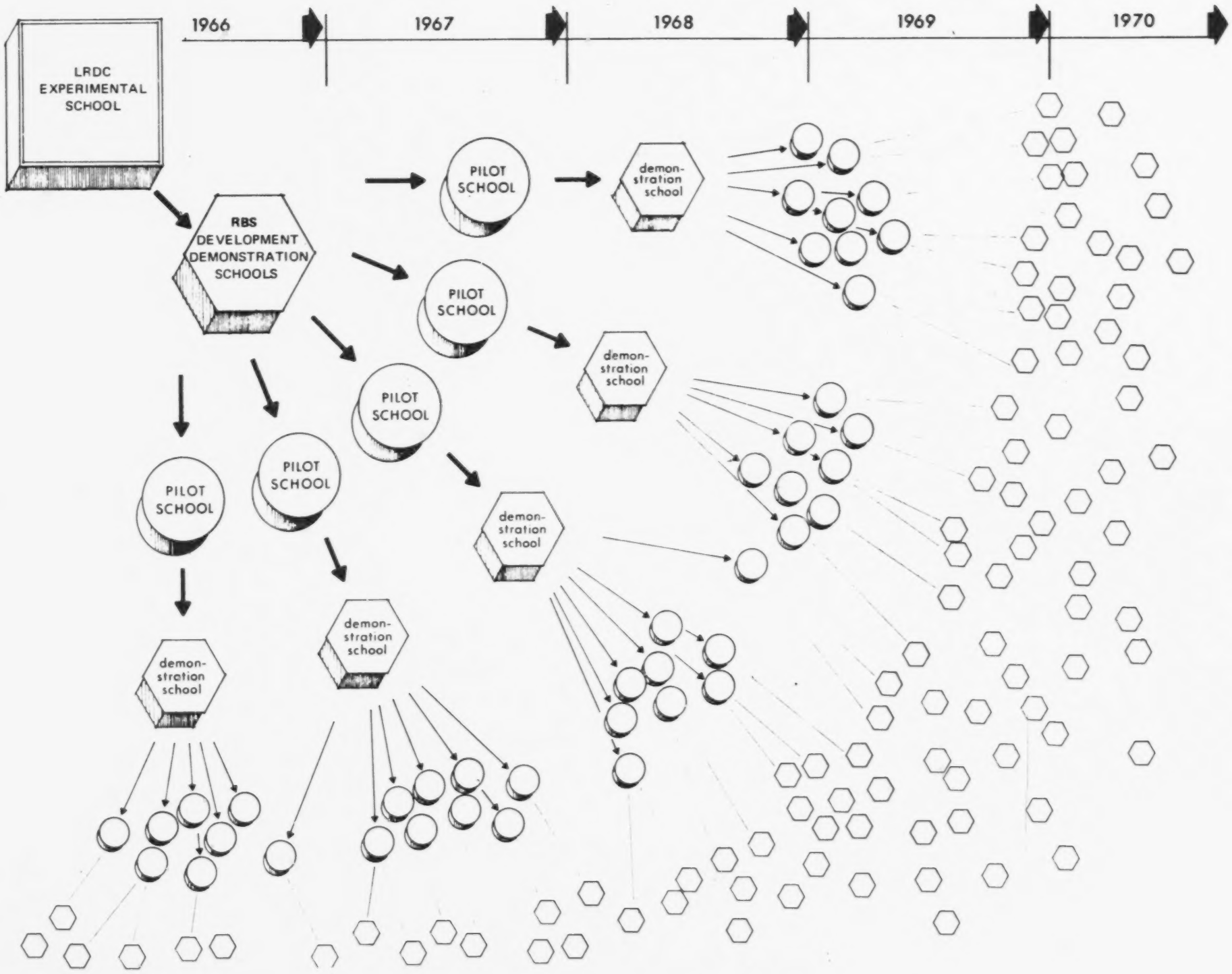


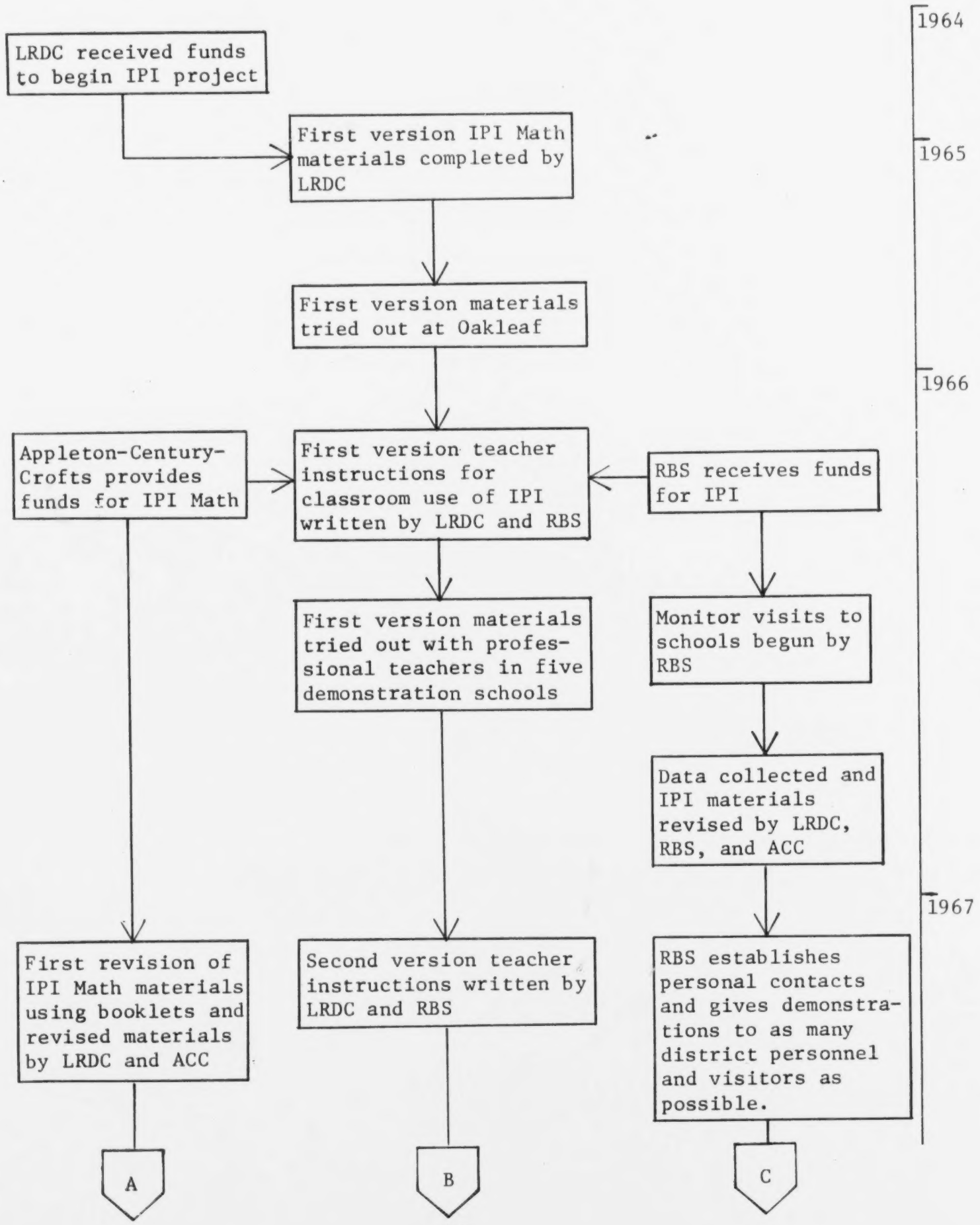
Figure 4. Phases of IPI Diffusion

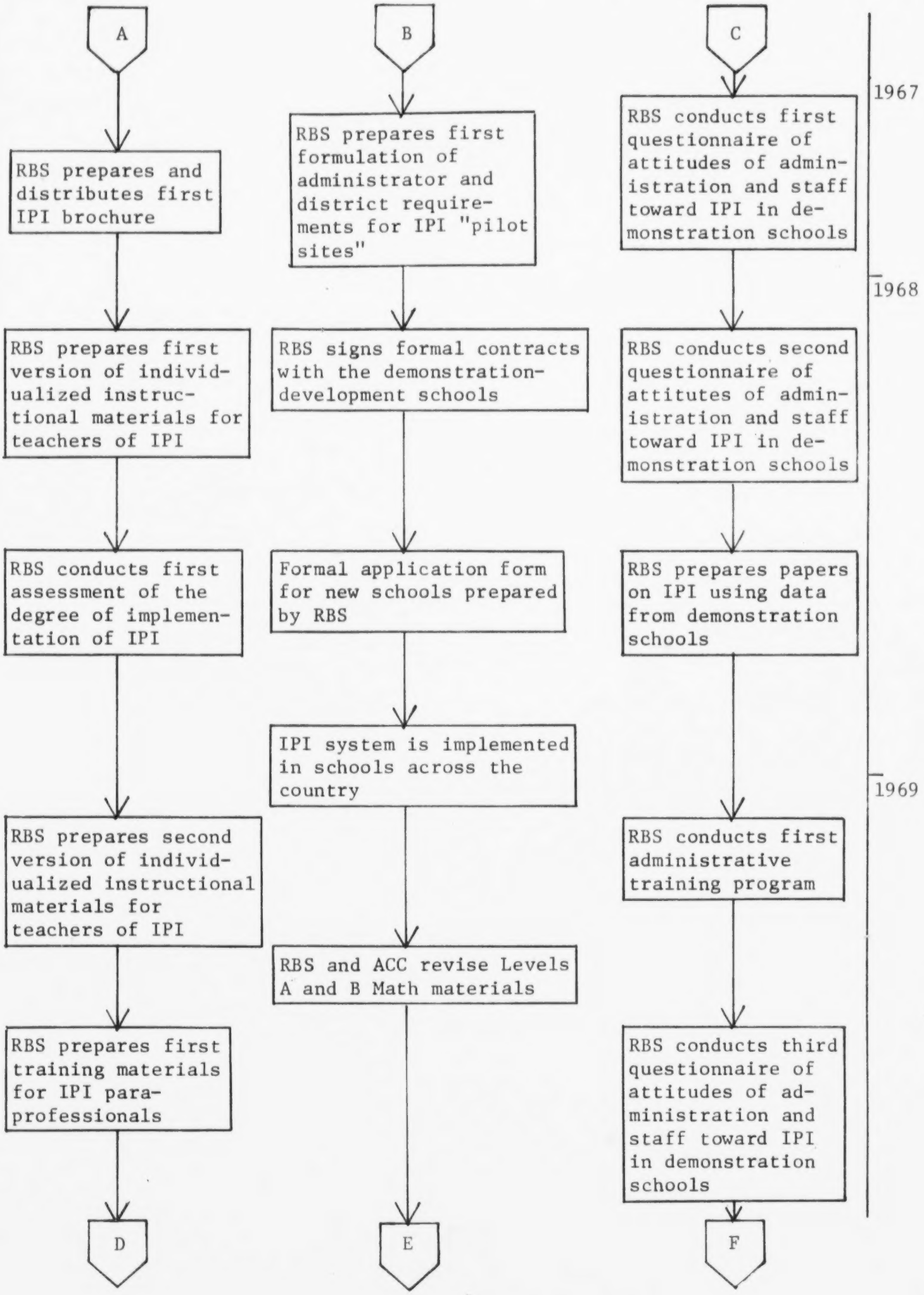
FISCAL 1966	FISCAL 1967		FISCAL 1968		FISCAL 1969		
MAY-JUNE	JULY - AUGUST	SEPT. - JUNE	JULY - AUGUST	SEPT. - JUNE	JULY - AUGUST	SEPT. - APRIL	MAY - JUNE
Demonstration School organized at Baldwin-Whitehall School District in cooperation with University of Pittsburgh LRDC.	Conducts training program for LRDC staff, staff from five pilot schools and cooperating colleges.	Conducts training program for additional pilot school staff members.	Conducts training program for new teachers and remaining staff of pilot schools.	Pilot Schools become Demonstration Schools--original demonstration school phased out in Sept. 1967.	Training programs conducted by Demonstration Schools for new pilot schools.	Demonstration Schools schedule for large-scale visitation and observation by other schools.	
*Five pilot schools in RBS region selected--each school identifies four staff members for training.		IPI phased into the operation of the pilot school.	Organization of materials, schedules and teachers for program.	*Five new pilot schools selected for each demonstration school--some training conducted at demonstration schools.	Organization of materials, schedules and teachers for program.	IPI phased into operation of pilot schools.	Recommendations concerning the effects of the IPI program and the effects of the diffusion strategies made to the Board and to the region.
*Five cooperating institutions of higher education in RBS region selected. One person per institution trained. RBS central project staff identified and appointed.		Data collected on the effects of IPI concern 1) students, teachers from pilot school, and 2) the interest and involvement of other schools in the area.	Analysis of data collected during first year. Development of more refined assessment procedures and instruments.	Additional cooperating colleges and universities selected.	Old and new data types collected on Demonstration Schools and pilot schools.	Data collection and analysis.	
		*Site visits of the Demonstration School by 100 people from 50-100 schools caused by RBS.	*Site visits of remaining 100 people scheduled.	*Site visits scheduled by RBS staff for other regional schools.	- No site visits scheduled by RBS -	- No site visits scheduled by RBS -	

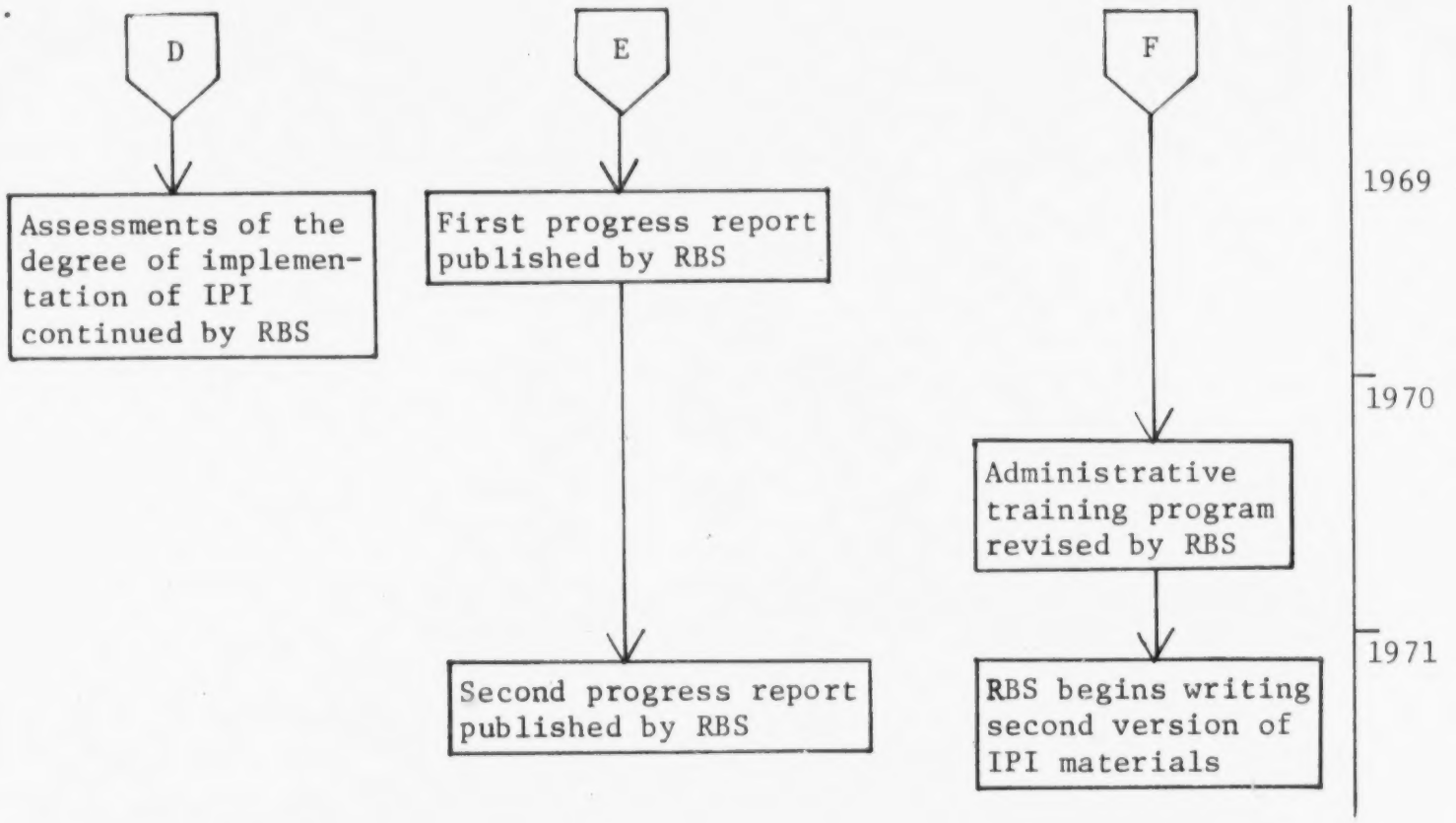
*Planned intervention by RBS.

Figure 5

Major Event Flow Chart


LRDC received funds to begin IPI project
First version IPI Math materials completed by LRDC
First version materials tried out at Oakleaf
Appleton-Century-Crofts provides funds for IPI Math
First version teacher instructions for classroom use of IPI written by LRDC and RBS
RBS receives funds for IPI
First version materials tried out with professional teachers in five demonstration schools
Monitor visits to schools begun by RBS
Data collected and IPI materials revised by LRDC, RBS, and ACC
First revision of IPI Math materials using booklets and revised materials by LRDC and ACC
Second version teacher instructions written by LRDC and RBS
RBS establishes personal contacts and gives demonstrations to as many district personnel and visitors as possible.
A
B
C
1964
1965
1966
1967


A
B
C
RBS prepares and distributes first IPI brochure
RBS prepares first formulation of administrator and district requirements for IPI "pilot sites"
RBS conducts first questionnaire of attitudes of administration and staff toward IPI in demonstration schools
1967
RBS prepares first version of individualized instructional materials for teachers of IPI
RBS signs formal contracts with the demonstration-development schools
RBS conducts second questionnaire of attitudes of administration and staff toward IPI in demonstration schools
1968
RBS conducts first assessment of the degree of implementation of IPI
Formal application form for new schools prepared by RBS
RBS prepares papers on IPI using data from demonstration schools
IPI system is implemented in schools across the country
1969
RBS prepares second version of individualized instructional materials for teachers of IPI
RBS conducts first administrative training program
RBS and ACC revise Levels A and B Math materials
RBS prepares first training materials for IPI paraprofessionals
RBS conducts third questionnaire of attitudes of administration and staff toward IPI in demonstration schools
D
E
F


D
Assessments of the degree of implementation of IPI continued by RBS
E
First progress report published by RBS
Second progress report published by RBS
F
Administrative training program revised by RBS
RBS begins writing second version of IPI materials
1969
1970
1971

29

Modifications of Original Development Plan

Over the summer of 1966, five demonstration and development schools were selected. Each of the demonstration/development schools served a different socioeconomic population. The first school selected for demonstration/development purposes was the McAnnulty School in the Baldwin-Whitehall School District of Pittsburgh. It was intended that this school would maintain close contact with the Oakleaf School and would serve a training function for staff in the other demonstration school while helping to take off some of the pressures of visitation from Oakleaf School. Schools were also selected from the communities of Harrisburg and Quakertown, Pennsylvania; Dover, Delaware; and Trenton, New Jersey. Staff from these schools gathered in the summer of 1966 at the University of Pittsburgh to receive initial training in implementing the IPI system in mathematics. These courses were conducted as part of the regular University of Pittsburgh summer session. As a result, school personnel attended the courses whose schools were not among those designated among the original five demonstration and development schools. In fact, staff from as far away as Monterey, California, were involved in these original training sessions. This resulted in a need to modify and expand the plans for distribution of IPI materials and training of teachers and administrators.

Secondly, the interest that was generated nationwide by public accounts of the IPI program was much broader than had been anticipated, even though RBS had employed the services of a full-time public relations representative. During the 1966-67 school year, RBS was deluged with requests for more information about, and an opportunity to participate in, the IPI program. Several thousand visitors were hosted in the five demonstration schools during the first year. As a result, the policy of limited expansion envisioned in Figures 3 and 4 had to be considerably modified. This resulted in the establishment of a large number of schools implementing IPI outside of the demonstration network and necessitated the compilation of a policy for controlling the rate of expansion.

Thirdly, an initial meeting conducted in 1966 with representatives of teacher training institutions in the RBS area indicated a distinct lack of interest in the development of a program for training and retraining teachers in the use of Individually Prescribed Instruction in cooperation with RBS. Thus, the brunt of the development of training procedures fell back to RBS and had to be carried along with the other development and dissemination

activities. In addition, a sixth demonstration school was added in Wilkes-Barre, Pennsylvania.

In brief, widespread public interest generated by initial publicity and a wider than anticipated initial audience in the IPI training sessions revealed at a very early stage that the originally planned phases of IPI diffusion were inadequate. In order to meet these demands, it was necessary for RBS staff to increase their commitment and become more heavily involved in training activities than had originally been envisioned. The initial commitment to development of a systematic way of collecting data about the progress of students in the IPI system, the assessment of the degree of implementation of IPI in designated participating schools, and the modification and improvement of IPI learning methods and materials was maintained as had been intended.

Actual Procedures for Development of Product

The initial challenge of the first operational school year in the five development/dissemination schools was simply to put the system into operation. Materials had to be hastily collected from Oakleaf School and printed in sufficient quantities to go around to the five development schools. With a staff of three, Research for Better Schools' assets were sorely tested by this task alone. At times the materials production was only a week ahead of students in the classrooms. Members of the RBS staff contacted participating teachers in the demonstration schools at least once a week following the initial training during the summer of 1966. Most of the changes that took place in the materials at this time were done on an on-line basis by teachers in the participating classrooms, simply to make them functional for their students. Very little documentation is available on this process.

During the summer of 1967, following the crush of implementing the project in the five demonstration schools during the 1966-67 school year, several activities were undertaken. These were initiated partially because of the extreme interest which had been generated by the first year tryout, and partially because of the lack of interest by teacher training institutions in the area in the development of a cooperative teacher training and retraining package for IPI. The first effort was to establish a general strategy for the involvement of schools with IPI. Four specific criteria were established to insure commitment to and understanding of the project as a

prerequisite for cooperative involvement during the 1967-68 school year. Approximately 15 schools were to be selected as "pilot" schools on the basis of these criteria. They were as follows: (1) administrative commitment; (2) administrative training programs; (3) teacher retraining programs; and (4) development of a data network and feedback system that permits the monitoring of schools in terms of the progress students are making and in assessing the degree of implementation of IPI. These points will be reviewed in sequence.

The following criteria were established to elicit understanding about the IPI system and to insure administrative commitment to that system by the participating school:

1. Administrative commitment. This required the filling out of a self-study questionnaire by the local school administration testifying to the awareness of the human, physical, and financial resources required at the local level to implement the IPI system.

2. Teacher commitment. This involved the determination of the awareness of the participating school's faculty about the requirements for the implementation of IPI and their commitment to the retraining necessary to successfully implement IPI in their school.

3. Research participation. This involved an agreement to cooperate in providing specific kinds of data to RBS for the improvement of the instructional system.

4. Personnel training. This involved the agreement for all participants, including administrators, teachers and paraprofessionals, to undergo the required IPI training, which at this stage involved attendance at the 1967 summer workshop in Pittsburgh.

5. Uniqueness of situation. This criteria tried to take into consideration the past history of the school relative to success of efforts to promote individualization.

The second phase of the strategy involved the retraining of administrators, specifically principals in the elementary schools which would be participating as part of the 1967-68 field tryouts. Elementary principals had to be retrained about the organization necessary to provide flexible scheduling, permitting children to utilize both the professional and non-professional services as

required by the IPI system. In addition, the principal had to be retrained to acquire new skills in the analysis of data so that he would be able to effectively utilize the flow of information passing over his desk concerning the performance of the teachers and students in his school in implementing the IPI system. Finally, the principal had to know how to talk to his staff, receive information from it, and involve the staff in decision-making regarding the implementation refinement.

Teacher re-education efforts, the third phase of the involvement strategy, concentrated on the development of necessary skills needed by teachers in implementing the system. Specific objectives of the 1967 teacher training program were to allow teachers to define and list their functions in Individually Prescribed Instruction, to provide necessary preparation for these functions, and to discuss problems of interaction between administrators, teacher aides, and students. Techniques included lectures and small group discussions on common problems led by an expert, i.e., a teacher from one of the demonstration schools who had utilized the system the previous year. Following the 1967 summer sessions and acting on a suggestion that they practice what they preach, RBS staff began the construction of a teacher retraining system based on the IPI model, containing behavioral objectives, pre- and posttests on the objectives, self-instructional materials and equipment, and recommended learning settings providing concept building related to IPI, analysis and application of the concepts to IPI, practice in using IPI skills and materials as routine exercises, role-taking as a teacher aide and student while working through the math continuum, discussions designed to provide an opportunity for clarification, and expression of reactions to IPI.

The fourth phase of the implementation strategy, the development of a monitoring system, was initiated by a team of monitors from the RBS staff. These monitors visited participating schools approximately once a month to collect data on each school and to help resolve its problems. Information was to be collected about the materials, the activities of pupils and teaching staff, the reactions of the community, and the general performance of the IPI system in helping pupils attain the objectives of IPI.

Formative Evaluation

Directly from the beginning, formative evaluation in IPI was somewhat different from the formative evaluation for individualized programs such as AIR's Project PLAN. The developers of IPI early discerned a trend toward a

wide variance in degree of implementation of the IPI system among the demonstration schools who were utilizing the system under RBS's general supervision. One of the main RBS efforts, then, after the initial push to get materials into the field, was the development of a Degree of Implementation report. This report was seen as a realistic method for monitoring the degree of IPI implementation in three major categories: (1) the use of diagnostic instruments; (2) the use of instructional materials; and (3) the use of individual student planning sessions. The data collected for this monitoring report were thus used for both assisting participating schools in improving the degree to which they were implementing the IPI system, and also in improving the IPI system where flaws were noted.

The basic philosophy of IPI evaluation is documented in the fifth monograph in the AERA series on curriculum evaluation entitled Evaluation as a Tool in Curriculum Development: The IPI Evaluation Program, authored by C. M. Lindvall and Richard C. Cox in collaboration with John O. Bolvin. The four major questions to be answered by the IPI evaluation are as follows. (1) What goals should the program achieve? (2) What is the plan for achieving these goals? (3) Does the operating program represent a true implementation of the plan? (4) Does the program when developed and put into operation as intended achieve the desired goals? These four categories also represent the four sequential steps in planning and developing a program. The interdependence of these steps with the continuing assessment of student performance is seen as the major departure between this approach and other concepts of formative evaluation.

This approach to evaluation views the evaluator's refinement of program objectives as a logical and necessary part of his role. The evaluator raises such questions as: (1) Are the statements of program goals actually objectives? (Objectives for an instructional program should tell one exactly what he can look for as evidence of success once it has been carried out.) (2) Are the stated objectives the real goals of the program? (3) Are the goals worthwhile? (4) Are the goals obtainable?

In assessing the plan of implementation, the evaluator seeks answers to the following questions:

1. Does the plan give promise of contributing to the achievement of the goals? Concerning each part of the plan, the evaluator asks, which specific goals is it designed to achieve and how will it accomplish it?

2. Is the plan developed in sufficient detail?

3. Will the plans and procedures be easily understood by the people who are to put them into operation? Plans easily understood by the program developer and the evaluator may still be difficult for teachers to comprehend and, therefore, ineffective for use in program implementation.

4. Is it probable that the plan can be carried out?

The third phase of the evaluation involves the aforementioned observation of the various aspects of implementation: pupil activities, teacher activities, and whatever else is involved in implementing the program. This implementation monitoring also includes performing observations on the effectiveness of material such as lessons and tests and other formal operational procedures. Questions used as guidelines include:

1. What are the specific points to observe in performing the operation analysis? What should the pupils be doing according to the plan? In what activities should teachers be engaged? What other personnel are involved and what should they be doing?

2. Are the activities actually being carried out according to the plan? Both formal and informal observations and the collection of data generated by the program in the form of pre- and posttests and curriculum-embedded tests may be collected.

3. How can the operation be made to correspond more closely to the plan? This includes the collection of suggestions for shaping the operating program so that it can more truly represent the planned program.

4. Does a study of the actual operation suggest any modifications in the plan?

The final component of the IPI evaluation model is the assessment of the results of the program in attaining the designated goals. The most important task is to obtain valid information that provides the direct evidence concerning the achievement of each designated goal. The evaluator, in planning and examining procedures for the assessment of outcomes, gives attention to the following types of questions:

1. Are all program goals assessed?

2. Are the assessment procedures reliable, that is, free from random error?

3. Does the evaluation provide an adequate total picture of the program results suitable to the needs of potential users, including unintended outcomes?

4. What are the implications of the results for modification of the program?

It can be seen, then, that the IPI evaluation program has been very closely geared to assessing the objectives, operation, and degree of implementation of IPI in the demonstration and pilot schools. Such assessment is seen as prerequisite to both formative and summative evaluations which can be made by whoever has access to the data. Program developers are most seriously concerned with those data which represent suggestions for possible improvements in the functioning of the program, while potential users are more interested in those data which represent the overall worth and effectiveness of the program when compared with the performance of whatever standard they choose to assign.

Techniques used to gather information. Since the evaluators in the early stages of the development of IPI were also heavily concerned with the development and implementation of the system, their role in the refinement of program objectives and the planning for implementation of IPI was difficult to isolate from their role as developer. These phases of the evaluation will not be considered further. Of more general interest are the techniques utilized in monitoring the implementation of the program in the developmental and pilot schools. Several basic sources of information were tapped. The first, of course, was the data stemming from student performance on the placement tests, pre- and post-unit tests, and curriculum-embedded tests, which are part of the IPI system. Since the IPI testing program placed a major emphasis on content validity, i.e., IPI test items measure quite exactly the attainment of specified curriculum objectives, these data had clear utility in determining the extent to which objectives were being attained by participating students. Tests which emphasized content validity in such a manner have been termed criterion-referenced. Indeed, Robert Glaser is generally attributed as the originator of this term. Such tests, which provide for individualized diagnosis and guidance of pupils through pre-design instructional programs also, by definition,

provide useful information about the degree to which curriculum objectives are being achieved. Other objective data were collected in terms of students' rate of learning, as evidenced by the time required to progress from point to point in the hierarchical curriculum, classroom observation conducted by trained observers to examine teacher, pupil, and teacher aide implementation of desired procedures, as well as more conventional techniques such as student attitude inventories, interviews with parents, interviews with pupils, teacher ratings, etc. In addition, standardized achievement tests were sometimes used in formative evaluation. The second progress report on IPI, published by Research for Better Schools in March of 1971, contains reference to over 30 studies conducted between 1966 and 1971 by LRDC, RBS, and participating school personnel, whose goal was the improvement of the performance of IPI Mathematics.

Procedures for modifying product on the basis of evaluation results. Materials which were utilized in the five demonstration schools during the 1966-67 school year had been taken directly from those being utilized in Oakleaf School. In general, these materials were either adapted from existing mathematics textbooks or had been constructed by LRDC and Baldwin-Whitehall staff to result in student attainment of objectives for which existing educational materials did not seem appropriate. Commercial programs were, in general, selected on the relatively inadequate grounds of reputation, personal liking, history of previous use, and diversity in representing the broad spectrum of approaches consistent with the existing Baldwin-Whitehall mathematics curriculum. Following the 1966-67 tryout of these materials, which existed, primarily in rather unorganized format, in the form of scattered worksheets sometimes reproduced directly from existing educational materials along with the other accoutrements of the IPI system, the 1967-68 edition of IPI materials was published by Appleton-Century-Crofts. These materials represented the first major revision of the IPI system that had existed in Oakleaf and for the first time brought together in a standardized format all of the diverse IPI learning material and testing instruments. Extensive changes in the ordering of objectives had been made at the upper levels of the mathematics program based upon evidence that some objectives were proving too difficult at the stage at which they were assigned. Other objectives were not only easy at the stage at which they were assigned, but it appeared that earlier introduction would facilitate later learning. An example of this can be found in the fraction sequence. Delay of the introduction of "greatest common

denominator" and "least common multiple" delayed the development of other concepts using fractions. Therefore, these objectives were moved to an earlier position.

Revisions were made both by members of the LRDC and RBS staff and by teachers who participated in the five demonstration schools. Editorial and pictorial revisions were accomplished by staff of Appleton-Century-Crofts. A page-use analysis was made of pages and worksheets as they existed in the 1966-67 version of the IPI materials. Worksheets which were not extensively used were eliminated. It is important to note the time for revision of existing materials in the IPI system at this stage. When additional pages were needed or old pages proved ineffective in terms of bringing about student gains on unit posttests, changes were instituted on these individual materials. The time required to institute a fairly extensive change, i.e., a major change in the method of teaching addition of fractions, was about one month. This relatively short time for a revision is to be compared to the minimum of a year for any commercial workbook. Also to be noted is the fact that a unit or page could be revised which, in general, would not be considered important enough to cause the revision of an entire workbook. A final general direction of the revisions was the fact that in most pre-existing instructional materials, self-instruction for completing the work on the pages was lacking, since in a normal class the entire group would be given working directions by the teacher. In the individualized program this was not possible; therefore, it was necessary to continuously construct and update student directions to allow them to function in a self-instructional manner.

Of additional interest in terms of the general dissemination model of IPI was the use of teacher complaints about the summer 1967 training workshop as an impetus toward the development of an individualized teacher training package.

Number and description of iterative cycles. In a sense instructional materials and procedures in IPI Mathematics have been continuously revised due to the modular nature of the curriculum. Individual student learning units and tests could be revised and phased into the curriculum in the five developmental and 15 pilot study schools as decisions were made about inadequacies or improvements. Changes were always made first within the demonstration schools where almost continuous contact with RBS staff was maintained.

When changes proved to be effective in these schools, the materials could then be finalized and sent out to the pilot schools where less frequent contact was maintained. In a sense, then, the pilot schools were always one phase behind the demonstration schools which, in turn, are a phase behind the Oakleaf School where LRDC is continuing the development and modification of the new IPI Mathematics curriculum.

Major changes have been made in the system during the summers intervening the tryout years from 1967-68 to the present. As far as the mathematics curriculum is concerned, however, these changes have been more concerned with the preparation of IPI Math as a commercially acceptable product than with major changes in the curricular emphasis. This required that copyrightable materials which had been borrowed from pre-existing texts had to be modified to the extent that they would now be copyrightable by Appleton-Century-Crofts and, later, by whichever publishing company received the contract to proceed with the final commercialization of IPI Math in September of 1972.

SUMMATIVE EVALUATION

In a sense, a summative evaluation of IPI would represent a negation of the basic aspect of this program. Because a major feature of IPI is that it is being continuously modified on the basis of student performance data, it should never become a fixed program to be given a final assessment. The total IPI system and each of its many components, i.e., the testing program, prescription writing procedures, teacher-classroom procedures, etc., have been observed and continuously improved. Data to suggest that this improvement has indeed taken place is presented in the AERA curriculum evaluation monograph showing a general increase over time in student performance on fairly constant sets of objectives. Under this type of curriculum evaluation model, if the current version is not yielding the desired educational results, the system itself provides data to demonstrate this and suggests necessary modifications which can be instituted. With this approach to program development, there is really no final summative evaluation. There is only summative evaluation for a given stage describing what results are produced by a program at that stage. As has been mentioned previously, the existence of an IPI monitoring system related to the degree of implementation of IPI in a particular class further allows the mediation of judgments of overall worth of the system,

when compared to selected non-IPI programs, on the basis of the degree to which the IPI program is being implemented as intended.

Thus, results on such summative evaluation devices as standardized tests must be considered purely descriptive of how IPI students working on a particular type of school in a particular type of community do on whichever tests are given typically in that school. Such results provide additional information concerning what pupils learn under IPI, but are essentially an invalid step in evaluating the effectiveness of IPI in attaining its objectives. Standardized tests currently available do not measure student achievement of the type that is defined in the sequences of instructional objectives for IPI Math. However, since descriptive information concerning the achievement of IPI students on standardized tests may have considerable meaning for the potential user of IPI, the second progress report on IPI presented in March 1971 by RBS contains over 25 references to summative evaluations in which comparisons were made on both standardized indicators and indicators of affective and psychomotor output between IPI and control conditions. In general, these results are summarized as follows:

> Students achieve as well or better than non-IPI students on standardized tests, achieve higher than non-IPI students on IPI tests, have a positive attitude toward schools and learning, and demonstrate a change in social behavior.
>
> Parent reactions have been highly positive indicating that their children like school better. Parents also feel that IPI considers individual differences and is a successful experience and that IPI is superior to traditional mathematics programs.
>
> Administrators can be taught to use the system, become the instructional leaders for their own staff and use data to manage the instructional system.
>
> The IPI system has produced effective results with a variety of populations: disadvantaged, rural, mentally retarded as well as regular populations [p.8].

FUTURE OF THE PRODUCT

The culmination of the final revision of the Mark II version of IPI Math will become commercially available in September 1972. A nationwide system of demonstration and training schools will be developed with schools in each state equipped to both demonstrate the IPI Math system in operation and assist in training new administrators, teachers, and teacher aides in the implementation of the product. The Mark III version of IPI, currently being utilized in Oakleaf School under the supervision of LRDC staff, will be more heavily oriented toward modern math than is the Mark II curriculum, and will contain materials such as mathematics laboratories, etc. Mark III materials have already begun to be implemented in the demonstration schools, indicating that it may be from two to three years before these materials will be available commercially, based on Mark II experience.

CRITICAL DECISIONS

The following events are an approximation of crucial decisions which were made in the development history of IPI Mathematics. Although an attempt has been made to arrange these decisions in a rough chronological order, it must be stressed that such events do not usually occur at one point in time, nor in strict sequential order.

Decision 1: LRDC to Develop a Program of Total School Individualization

A number of crucial assumptions were implied in this decision. First, LRDC proposed to stress an individualized approach as opposed to a traditional group approach to instruction. Second, LRDC chose to modify the entire educational program of the conventional school rather than isolated segments of this program. Developments which supported these decisions included the formulation of a mastery model of student learning and an educational technology capable of supporting total classroom individualization.

Decision 2: LRDC to Utilize Oakleaf School for Immediate Implementation

LRDC could have chosen to implement their school individualization efforts on a smaller scale in-house or on a much larger scale utilizing several schools simultaneously. The establishment of a working arrangement with the Baldwin-Whitehall School District to utilize Oakleaf School facilities and personnel had several major implications. First, it meant that procedures had to meet certain practical constraints in their initial applications rather than allowing the luxury of several trials to achieve

each desired outcome. Second, it meant that the procedures had to be within the immediate implementation capabilities of relatively unsophisticated classroom teachers rather than special LRDC personnel trained for the purpose. Finally, it meant that implementation efforts could take place on a scale small enough to allow continuous personal developer contact and revision.

Decision 3: LRDC to Focus on the Revision of Instructional Methods Rather Than the Development of New Curricula

Even though Decision 1 dictated that much of the existing school subject matter would be included in IPI, it would have been possible to attempt to begin from scratch and formulate entirely new curricula. The decision to attempt immediate implementation virtually guaranteed that the existing curriculum in the Baldwin-Whitehall district would be accepted as the basis of the IPI curriculum, and this was especially true of IPI Math. The curriculum thus based on existing materials tended to stress a conventional approach to mathematics education rather than the so-called "new math" approach, which was just becoming available. It was possible to select and isolate existing objectives to structure the IPI system rather than forcing the construction of an entirely new set of objectives. This decision may have caused some long range problems in terms of the recency of the curriculum, but it was a prerequisite for immediate field implementation.

Decision 4: LRDC to Utilize Services of a Commercial Publishing House During Initial Development

The decision to utilize the expertise of the New Century Publishing Company in the initial development of IPI Math materials in return for a limited copyright concession on the resultant products was probably of crucial importance in the early availability of relatively sophisticated materials for dissemination by RBS. While LRDC could have utilized in-house expertise to package the instructional system in IPI Math, the LRDC team acknowledged that they were not expert in that line of endeavor and consequently solicited the assistance of an organization that was. This decision is in direct contrast to the decisions of other development agencies contacted during this project who either elected to wait until a completely functional product was available before calling in commercial publishers, or elected to serve as their own distributors and have never become allied with commercial enterprises.

Decision 5: LRDC to Focus on the Elementary Level Program

The alternatives open were preschool, elementary, secondary, and college. Since it was felt that very little can be done in the way of education without

the development of a sound foundation, the decision was made to focus on preschool and elementary education. Within preschool and elementary, the kindergarten and lower primary grade levels were selected as having the most potential for the development of a useful foundation in the basic skills areas.

Decision 6: IPI to Utilize Paraprofessional Aides Rather Than Computer

Immediate implementation of an individualized system within existing technology required a considerable amount of clerical support; at the time this was only obtainable through the use of paraprofessional clerical aides in the classroom. Although LRDC formulated long range plans to utilize computer support for the clerical function, IPI Math, as it evolved, became dependent on paraprofessional assistance for adequate implementation. In view of the tremendous cost and reliability problems encountered by systems which attempted to utilize computers from the beginning, this decision may have been especially influential in the ultimate wide dissemination and use of IPI Math.

Decision 7: RBS to Disseminate IPI Math

The justification for this decision, which really predated the formulation of RBS as a federally funded regional laboratory, has been covered at length earlier in the text of this report. As a result of this decision, RBS became closely identified nationwide with IPI and later undertook the further development of the product which was necessary to allow its installation on a larger scale.

Decision 8: RBS to Create and Utilize a Demonstration School Network

This decision required a fundamental assumption about the nature of the change process in education. Since the original RBS goal was widespread dissemination of IPI, this decision implied that the goal could best be attained by allowing interested educators to see IPI in operation. The fact that RBS was a regional laboratory representing three states also required that the demonstrations be geographically diffuse within the region and politically advantageous in their exact locations.

Decision 9: RBS to Engage in Further Development Activities

Although the original intent had been primarily to disseminate an already functioning product, it soon became apparent that the Oakleaf version of IPI Math was not sufficiently perfected to slip untouched into demonstration classrooms in the RBS region. This fact necessitated either further develop-

ment activities by LRDC, the involvement of RBS staff in development, or the abandonment of the RBS dissemination plan. The RBS development option was selected, and this, in turn, resulted in the creation of a second mission with RBS--that being the evaluation and improvement of IPI Math. Ultimately, the development staff was to become larger than the dissemination staff and their separate identities would blur into an indistinguishable glob.

Decision 10: RBS to Develop Teacher Training Materials to Accompany Student Materials

The original plan had been to get teacher training institutions in the RBS area to develop a program for training and retraining teachers in the use of IPI. Since the representatives of these institutions showed a decided lack of interest in developing a teacher training and retraining package, it was necessary for RBS to develop teacher training materials to accompany the student materials. This was done in conjunction with the other development and dissemination activities.

Decision 11: RBS to Continuously Evaluate and Revise the Educational System in Demonstration School Network

The alternatives open under this decision were the continuous formative evaluation and revision of the product as opposed to the development of the product in-house with a final comparative-type summative evaluation. As is apparent from the Major Event Flow Chart on pages 22-24, the strategy of developing, revising, and further developing, which has been called formative evaluation, was the option selected.

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APPENDIX A

IPI DEVELOPMENT COSTS (RBS)

	6/16/66-11/30/66	12/1/66-2/28/67	3/1/67-11/30/67	12/1/67-11/30/68	12/1/68-11/30/69	12/1/69-11/30/70
TOTAL COSTS	364,604	148,897	795,105	1,275,229	1,758,862	1,968,503

46

APPENDIX B

ACTIVITIES PERFORMED BY INDIVIDUALIZED LEARNING PROGRAM PERSONNEL IN THE FIVE MAJOR FUNCTIONAL AREAS

Curriculum Writing

1.1 Write a rationale.
1.2 Specify objectives.
1.3 Create sources and materials.
1.4 Identify specifications for training materials.
1.5 Define variables for formative measurement.

Material Production

2.1 Provide for needed curriculum communication material.
2.2 Schedule production of materials.
2.3 Create graphics, printed, recorded, visual.
2.4 Produce communication materials.
2.5 Distribute communication materials.
2.6 Define variables for formative measurement.
2.7 Perform quality and quantity control on the production of materials.
2.8 Coordinate logistics for curriculum writing.

Training

3.1 Write rationale.
3.2 Specify objectives.
3.3 Create sources and materials.
3.4 Develop training program based on specifications.
3.5 Conduct training program.
3.6 Define variables for formative measurement.

Field Engineering

4.1 Diagnose school operations.
4.2 Assist with training program.
4.3 Develop strategies for intervention.
4.4 Develop strategies for improving program.
4.5 Define variables formative measurement.
4.6 Define variables summative measurement.

Appraisal

5.1 Define formative evaluation.
5.2 Perform formative evaluation.
5.3 Define summative evaluation.
5.4 Perform summative evaluation.
5.5 Design school self assessment devices.
5.6 Develop school self assessment devices.

APPENDIX C

LIST OF PRODUCTS AND DEVELOPERS

The following is a list of products for which Product Development Reports have been prepared.

Arithmetic Proficiency Training Program (APTP)
Developer: Science Research Associates, Inc.

The Creative Learning Group Drug Education Program
Developer: The Creative Learning Group
Cambridge, Massachusetts

The Cluster Concept Program
Developer: The University of Maryland,
Industrial Education Department

Developmental Economic Education Program (DEEP)
Developer: Joint Council on Economic Education

Distar Instructional System
Developer: Siegfried Engelmann & Associates

Facilitating Inquiry in the Classroom
Developer: Northwest Regional Educational Laboratory

First Year Communication Skills Program
Developer: Southwest Regional Laboratory for
Educational Research & Development

The Frostig Program for Perceptual-Motor Development
Developer: The Marianne Frostig Center of Educational Therapy

Hawaii English Program
Developer: The Hawaii State Department of Education
and The University of Hawaii

Holt Social Studies Curriculum
Developer: Carnegie Social Studies Curriculum Development Center,
Carnegie-Mellon University

Individually Prescribed Instruction--Mathematics (IPI--Math)
Developer: Learning Research and Development Center,
University of Pittsburgh

Intermediate Science Curriculum Study
Developer: The Florida State University,
Intermediate Science Curriculum Study Project

MATCH--Materials and Activities for Teachers and Children
Developer: The Children's Museum
Boston, Massachusetts

Program for Learning in Accordance With Needs (PLAN)
Developer: American Institutes for Research and
Westinghouse Learning Corporation

Science--A Process Approach
Developer: American Association for the Advancement of Science

Science Curriculum Improvement Study
Developer: Science Curriculum Improvement Study Project
University of California, Berkeley

Sesame Street
Developer: Children's Television Workshop

The Sullivan Reading Program
Developer: Sullivan Associates
Menlo Park, California

The Taba Social Studies Curriculum
Developer: The Taba Social Studies Curriculum Project
San Francisco State College

The Talking Typewriter or
The Edison Responsive Environment Learning System
Developer: Thomas A. Edison Laboratory,
a Subsidiary of McGraw Edison Company

Variable Modular Scheduling Via Computer
Developer: Stanford University and
Educational Coordinates, Inc.